Treatment of Posttraumatic Infections of Bone

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Aggressive antibacterial therapy is important for the successful resolution of posttraumatic bone infection. However, the removal of dead sequestered bone is often also necessary to eliminate infection. Surgical implants often have to be removed as well, once there is no longer a need for stability. Cancellous bone grafting can often help promote bony healing in the defects that remain after debridement. Author's address: Rood and Riddle Equine Hospital, 2150 Georgetown Rd., P.O. Box 12070, Lexington, KY 40580. © 1998 AAEP.

1. Acute Infection
During the initial phases of posttraumatic infections of bone, soft tissue is the best indicator of the presence of infection. Abnormal soft-tissue inflammation, edema, retarded wound healing, and exudate present at the surface of the wound are common clinical signs. If there is a large surgical or traumatic wound, bacteria can create a soft-tissue infection, but in the acute phase the bone is usually protected because its blood supply comes from the medullary circulation. Therefore, acute infection is primarily a wound infection that can often be controlled before bone becomes infected if the bony blood supply remains intact.

2. Radiographic Appearance of Posttraumatic Infections of Bone
Acute posttraumatic infections of bone show no radiographic signs since primarily soft tissue is involved. If an infection persists long enough to irritate the periosteum, then periosteal proliferation begins 1-2 weeks postinjury. Viable periosteum produces mineralized tissue. If the underlying bone is viable, the new bone production will be attached to the parent bone. If the underlying bone is avascular and infected, the periosteal proliferation will not attach to the bone (Fig. 1). This is the first indication that a sequestrum or dead bone fragment is likely to form.

Between 4 and 6 weeks, viable bone and infected bone begin to separate. Cancellous bone reacts more quickly than cortical bone and will form a sequestrum more rapidly. Viable bone is demarcated from infected bone by a thin line of bone resorption that becomes progressively more distinct with time. If a fracture is present, the demarcation will follow the fracture line. If no fracture is present, the bone resorption will gradually appear at the margin of the infection.

Viable bone becomes less dense with time. Sequestrum density does not change because it is avascular and bone is neither deposited nor resorbed. The sequestrum often appears to become more sclerotic because the adjacent bone becomes demineralized and the developing granuloma surrounding the entire area begins to mineralize. The granuloma contributes to the summation density of the sequestrum, and the adjacent lucency adds to the contrast density of the sequestrum.

As the granuloma matures and the sequestrum...
separates, the central dead bone is surrounded by lucency, which in turn is surrounded by sclerosis. At some point, a fistula will form in the sclerotic bone to drain the exudate from the lucent area to the exterior. This fistula is the opening to the involucrum, which contains the sequestrum. The process is progressive and the granuloma continues to enlarge until the sequestrum is removed.

3. Chronic Infection
In chronic bone infections, the bacteria is established in the avascular bone. The key to treatment is re-establishing the blood supply to the infected bone. This is done by maintaining bony stability and preventing the buildup of exudate, which may cause excessive increases in local pressure.

If bacteria gain access to the medullary cavity, this creates the true clinical situation of osteomyelitis. A superficial infection of bone is really an osteitis since the medullary cavity has not been invaded. A lump develops at the site of the infection, and lameness occurs only with the accumulation of exudate. When exudate pressure exceeds vascular pressure, bacteria are forced into vascular spaces, further obstructing blood supply and propagating the infectious process [Fig. 2(a)].

4. Treatment
Antibiotics are useless in the eradication of infection in the presence of dead bone or implants. Antibiotics suppress bacterial growth and, therefore, reduce the exudate, but once the antibiotics are removed, the remaining bacteria begin to multiply again. If implants are necessary for the healing of a fracture, the implants must be left in place until bony healing has occurred; then the implants can be removed. If the implants and bone are unstable, then stability must be regained or the implants simply add to the infectious process. If a sequestrum is identified, it should be removed. The only exception would be the case in which temporarily leaving the sequestrum in place would aid stability.

Antibiotics cannot sterilize an infected cavity in the presence of an implant or dead bone because the glycoalyx or bacterial slime, which forms on the surface of the dead bone or implant, physically protects the bacteria from attack by white blood cells. Therefore, the normal body defense mechanisms are powerless to eradicate the bacteria. The removal of the dead piece of bone or implant is necessary to allow white blood cells to gain access to the remaining bacteria. Treatment is aimed at the removal of the foreign bodies, dead bone, and all of the surrounding glycoalyx, which has a mucous membrane type of appearance, and which will be closely adhered to the foreign body or dead bone. Bacteria are protected by this slimy layer and survive within it. The elimination of the foreign bodies or dead bone reduces the bacterial load and allows the normal body defense mechanisms to become active [Fig. 2(b)]. If there is a cavity present after the removal of the offending foreign bodies, a drain is inserted to prevent the accumulation of fluid within the cavity. Serum in a cavity is a fertile culture medium. Active suction drainage can be used; however, it is not necessary as passive ventral drainage is usually sufficient. If there is a large cavity that is in need of structural support or rapid revascularization, a bone graft can be useful. A bone graft will survive and reconstitute an infected cavity if it is protected from exudate and is accessible to a blood supply.

A restriction of activity is necessary only if bony structural integrity is interrupted. If the bone is stable, the prognosis is excellent that removal of the foreign bodies will resolve the infection. If instability is present, however, then the removal of the dead bone and implants will simply bring transient improvement because the progressive loss of blood supply will recreate more dead bone that protects the bacteria. In a minimally unstable situation, the removal of the foreign bodies may allow the healing process to progress and overcome the bacterial infection [Fig. 2(c)]. However, stability still must exist.

The prime need for unstable fractures is the establishment of relative stability between the bone ends. This is easier in the human patient because bed rest reduces motion. In a horse that insists on using the limb, exercise is detrimental and more extensive treatment is required. Implants should
Fig. 2. Infectious process of hematogenous origin: (a) resulting in a large metaphyseal sequestrum and a small epiphyseal sequestrum; (b) 2 weeks postsurgery, after sequestrectomy, drainage, and bone grafting; (c) long-term follow-up of the treated metacarpus.

Fig. 3. Comminuted open fracture of the metatarsus: (a) prefixation; (b) 6 weeks postfixation, demonstrating the development of instability (fractured screws) and a sequestrum (detached periosteal proliferation). The implants were tightened and replaced and a bone graft was added; (c) the healed fracture with the implants and sequestrum removed 8 months after the initial fracture.
not be removed if they are maintaining stability. For healing to be ensured, stability must first be obtained. However, unstable implants should be removed and replaced as necessary. Cavities that are relatively avascular can be aided by the addition of a bone graft, which also stimulates the production of new bone and improves the local biomechanical situation (Fig. 3). Systemic antibiotics are used to protect the soft tissue, especially if the surgical approach requires the incision of tissue that has been free from infection. In recent years, the addition of an antibiotic containing methyl methacrylate beads has greatly increased the ability to further reduce the infective load in an area of poor blood supply and has prevented the extension of infection in many cases while revascularization and healing are underway.

In any surgical manipulation in the presence of infection, soft-tissue exposure should be minimized. Getting the fracture to heal first is the most important goal; the remaining wound can be treated more successfully once this is accomplished. Once bone healing has occurred, implants are removed and the resolution of infection usually occurs routinely. Proliferative vascular bony callus that is present during sequestrectomy should generally be left in place to aid stability, as long-term remodeling will make excessive callus more cosmetically appealing.